Seismic hazard assessment in the volcanic region of Mt. Etna (Italy): a probabilistic approach based on macroseismic data applied to volcano-tectonic seismicity

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Abstract

In the framework of the UPStrat-MAFA project, a seismic hazard assessment has been undertaken in the volcanic region of Mt. Etna as a first step in studies aimed at evaluating the risk on an urban scale. The analysis has been carried out with the SASHA code which uses macroseismic data in order to calculate, starting from the site seismic history, the maximum intensity value expected in a given site with a probability of exceedance of 10% (I_{ref}), for a fixed exposure time. Depending on the aims of the project, hazard is estimated for local volcano-tectonic seismicity and short exposure times (10 and 30 years), without taking into account the contribution of "regional" events characterized by much longer recurrence times. Results from tasks A, B and D of the project have produced an updated macroseismic dataset, better performing attenuation models and new tools for SASHA, respectively. The maps obtained indicate that the eastern flank of Etna, the most urbanized sector of the volcano, is characterized by a high level of hazard with I_{ref} values up to degree VIII EMS, and even IX EMS locally. The disaggregated data analysis allows recognizing the "design earthquake" and the seismogenic fault which most contribute to the hazard at a site-scale. The latter analysis is the starting point to select the scenario earthquake to be used in the analyses of tasks C and F of the project dealing with, respectively, synthetic ground motion simulations and the evaluation of the *Disruption Index*.

Keywords: Volcano-tectonic earthquakes; macroseismic intensity; seismic history; attenuation models; exceedance probability; seismic hazard; disaggregation analysis; Mt. Etna; Italy.

1. Introduction

Earthquakes are by far the most relevant source of hazard for the densely urbanized areas of Mt. Etna. Local communities living on the eastern and southern flanks of the volcano suffer constant unease and economic losses, but also occasionally death toll, due to the high occurrence rate of damaging earthquakes. In fact, despite its low energy (M_L<5.2), volcano-tectonic seismicity is capable of producing severe damage and even destruction because of the shallow nature of hypocenters (Azzaro 2004; Alparone et al. 2015). Macroseismic intensities at the epicentre may even reach degree IX on the EMS (European Macroseismic

Scale, see Grünthal, 1998) but fortunately the related strong ground motions affect small areas owing to the rapid attenuation of seismic intensity that is typical of volcanic districts (for an overview in Italy, see Azzaro et al. 2006, 2013b and references therein). For this reason, studies aimed at assessing seismic hazard at Etna have been undertaken in the last years by means of a probabilistic approach based on the use of macroseismic data − "site approach" (Albarello and Mucciarelli 2002) – whose computational procedure was implemented by D'Amico and Albarello (2008) in the SASHA code. The contribution of the volcano-tectonic sources to the seismic hazard at a local scale was investigated by Azzaro et al. (2008, 2013a), exploiting as best as possible the huge historical dataset of earthquakes available for this area. In short, these analyses have demonstrated that seismic hazard in the Etna region is determined by two distinct seismotectonic regimes, namely regional earthquakes occurring in eastern Sicily ($6.2 \leq M_W \leq 7.4$) and local events due to sources in the volcano area, each characterized by different magnitude ranges and occurrence rates. The former prevail on long exposure times − typically 50 years, that correspond to a return period of 475 years for a 10% of exceedence probability (the standard interval used in the seismic hazard map of Italy, see Stucchi et al. 2011) – producing expected macroseismic intensity VIII MCS on a large part of Etna, with some spots up to degree IX in the eastern flank of the volcano (Gómez Capera et al. 2010). Conversely, the latter appear relevant on short exposure times (30 years or less), reaching the same aforementioned values of intensity in the sites located along some of the main seismogenic faults affecting the eastern flank of Etna. The hazard due to these structures has also been evaluated for short-term (5 years) earthquake rupture forecasts, investigating occurrence models under Poissonian (stationary) and time-dependent assumptions (Azzaro et al. 2012b).

The main target of the UPStrat-MAFA project is to assess seismic risk in urban areas through common approaches and tools for the selected test areas (Zonno et al. 2012). As for Etna, all the methodologies developed in the project have been applied: i) the probabilistic analysis of seismic hazard by using SASHA code, which has been implemented with additional functions to include synthetic effects deduced by physical/numerical simulations or to perform disaggregation analyses (D'Amico et al. 2015a); ii) the assessment of the buildings vulnerability, economic losses and replacement cost (D'Amico et al. 2015b); iii) the quantitative evaluation and mapping of the risk through the Disruption Index, a parameter which estimates the degree of the earthquake impact on urbanized areas considered as a complex system of infrastructural networks (Meroni et al. 2015); and finally iv) the estimation of ground-motion parameters (PGA, Housner Intensity) through EXSIM finite-fault simulations (Langer et al. 2015).

In this framework the seismic hazard assessment expressed in terms of macroseismic intensity is crucial to obtain a correct evaluation of the risk and hence its effective mitigation, due to the link with degree of damage which is inherent in the macroseismic scales. Although the SASHA code was still used for the analysis as in the previous studies, the results presented in this paper provide a more complete representation of hazard both in terms of maps and parameters that are important to identify the "design earthquake" for a given locality (Albarello 2012). In particular, the relevant differences (see Azzaro et al. 2013a) introduced in this study, can be summarized as follows: i) macroseismic dataset of the Etnean earthquakes updated to the periods 1600-1831 and 2010-2013; ii) probabilistic models of attenuation of the macroseismic intensity taking into account point and linear sources (Rotondi et al. 2015); iii) disaggregation analysis of data enabled by the new capabilities of the upgraded SASHA code.

This has led to improve the quality of the site seismic histories – the basic element considered by SASHA to compute the maximum intensity expected in a given exposure time, for exceedance probability thresholds – resulting from the integration of the intensities observed at a given locality (available macroseismic dataset) with the values calculated according to the attenuation models when the former are missing (virtual intensities). Finally, the disaggregation analysis performed for some localities of the eastern flank of Etna has allowed determining the most significant intensity or the equivalent magnitude/distance bins and, hence, to identify the seismic events that contribute most to the hazard of that site. Due to the aims of the UPStrat-MAFA project, the probabilistic seismic hazard assessment (PSHA) produced in this study refers only to the local volcano-tectonic seismicity and is aimed at improving the knowledge for short exposure time (30, 10 years).

2. Input dataset: historical catalogue and observed macroseismic intensities

Etna, together with Vesuvius, are probably the two volcanoes with the longest and most detailed historical records in the world. About ten years ago, the most recent portion of the huge historical data set of Etna was used to compile a macroseismic catalogue of earthquakes occurring in this region from 1832 to 1998 (Catalogo Macrosismico dei Terremoti Etnei, Azzaro et al. 2000). The CMTE catalogue has since been regularly updated − the last release covers up to 2013 (CMTE Working Group, 2014) − and adopted by the Italian parametric catalogue CPTI11 (Rovida et al. 2011) as the reference catalogue for the Etna region.

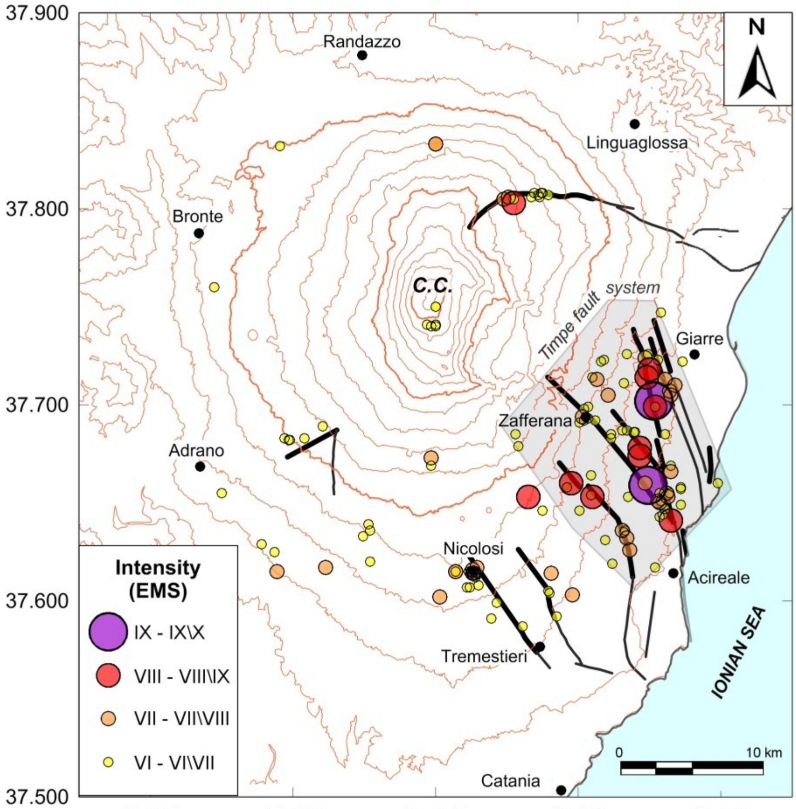

Fig. 1. Location map of damaging earthquakes ($I_0 \geq$ VI EMS) occurring in the Etna area from 1600 to 2013 (data from CMTE Working Group, 2014; Azzaro and Castelli 2015). Solid lines indicate the main active faults (from Azzaro et al. 2012a); C.C., central craters.

In this study we used, as input data, the intensity database and earthquake parameters of the CMTE catalogue, extending as far back as the year 1600, with new data coming from recent historical investigations (Azzaro and Castelli 2015). Overall the dataset covers the time-span 1600-2013. For the aims of the present work, we considered only the earthquakes above the damage threshold (epicentral intensity $I_0 \geq$ VI EMS), obtaining a dataset of 4432 intensity values referring to 140 events, with local magnitudes in the range from 3.0 to 5.2. As shown in Fig. 1, most of seismicity is located in Etna's eastern flank but it is noteworthy that all the destructive events (some ten with $I_0 \geq$ VIII EMS) occur in the area among the towns of Acireale, Giarre and Zafferana, the most populated sector of the volcano (Meroni et al. 2015). These earthquakes are due to the seismotectonic activity of the Timpe fault system (Azzaro et al. 2012a).

Regarding the distribution of the observed intensity data related to these events, Fig. 2a shows that the 415 localities (53 of which are municipalities) reported in the macroseismic database are "clustered" in the eastern flank, where there are major settlements – the city of Catania included – characterized by exceptionally well documented seismic histories (71-105 intensity data per site). Among them, the towns of Acireale and Zafferana, located on the boundary of the Timpe seismogenic zone (see Fig. 1), have more than 100 observations each. Many other municipalities (35) are also characterized by profuse seismic histories (31-70 intensity data per site), whereas those having a significant number of site observations (11-30) represent 17% of the total and include villages and a few municipalities (Fig. 2b). Finally, albeit many of the localities reported in the database (73%) have a low number of macroseismic observations (≤10), they refer to minor settlements or hamlets.

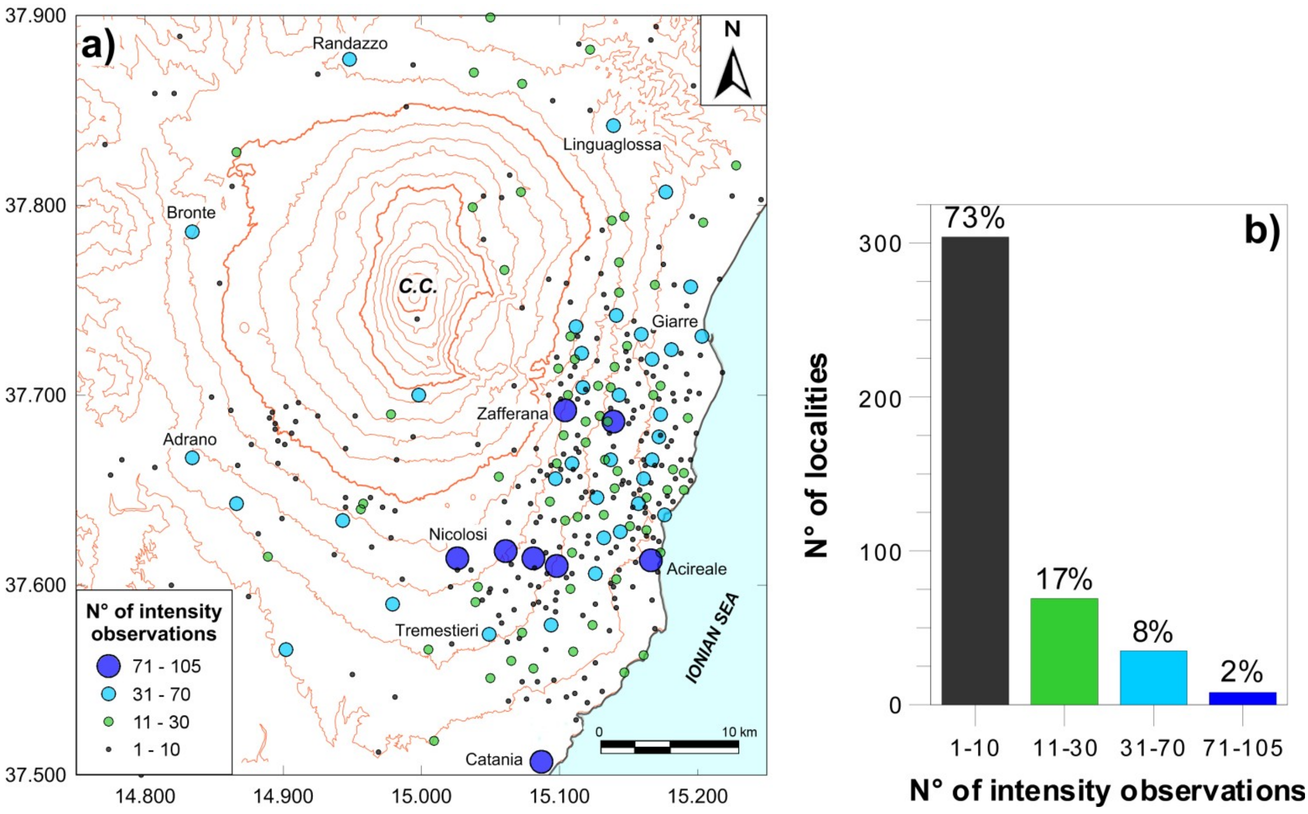

Fig. 2. a) Distribution and number of intensity observations for the localities reported in the macroseismic database, referred to the earthquakes above the damage threshold ($I_0 \geq$ VI EMS) considered in the study; b) Classification of the localities according to the number of intensity observations.

In conclusion, although the localities whose seismic history is well documented represent about 30% (112) of the sites considered in the hazard analysis, it is also evident that most of them appear densely distributed on the sector of the volcano most exposed to earthquake impact. This ensures that the contribution of real data (i.e. macroseismic intensities) in reconstructing the integrated seismic histories (observed plus calculated data) of important localities, is prevalent.

3. Macroseismic attenuation models: calculated intensities

To improve the completeness of the site seismic histories, the dataset of the observed intensities has been integrated with "virtual" values calculated through a probabilistic attenuation model, starting from the epicentral parameters (coordinates, I_0, M_L) of the earthquakes reported in the CMTE catalogue. This solution is applied only if the intensity data related to a given earthquake in the considered locality is missing.

Estimation of the attenuation model implemented in SASHA is performed according to Bayesian statistics. This gives the probabilistic distribution of the intensity at any site (Zonno et al. 2009), so that it is possible to quantify the intrinsic uncertainty of the decay process (Magri et al. 1994; Albarello and D'Amico 2004). It is a probabilistic binomial beta model conditioned on the distance site-epicenter and the value of the epicentral intensity I_0. The procedure to estimate the parameters of the binomial probability distribution is reported in Rotondi et al. (2015). A first version of this attenuation model was applied to the Etna region by Azzaro et al. (2013b) to reproduce the rapid decay of intensity of the shallow volcano-tectonic earthquakes in comparison with the crustal tectonic ones. Given these specific features of the attenuation pattern in this area, the model was developed for simulating: i) point sources (isotropic model) in which the decay is comparable to a symmetric spreading (circular), ii) linear finite sources (anisotropic model) in which the decay depends on the fault strike (elliptical). The entire procedure was implemented in the software PROSCEN to generate probabilistic seismic scenarios at Etna (Rotondi and Zonno 2010).

In this study, we used new parameters of the inverse power function calculated in the framework of the UPStrat-MAFA project by Rotondi et al. (2015), which modify the attenuation models previously determined in Azzaro et al. (2013b) by exploiting a larger learning set in assigning the prior distributions. The selection of the macroseismic fields to be used as a learning set in the isotropic and anisotropic models, was carried out according to the procedure described in Agostinelli and Rotondi (2015). The earthquakes in the CMTE catalogue having the value of I_0 expressed with an uncertainty, typically as intensity range (VII-VIII, VIII-IX etc.), are considered as being of lower degree; such a choice is due to a non-representative distribution of the highest intensity data points in the macroseismic fields. The new coefficients γ_1 and γ_2 (Tables 1 and 2) ensure a better fitting of the models to the observed macroseismic fields – now it is possible to simulate even events with I_0 VI according to the isotropic spreading – thus improving the hazard estimations obtained in this study.

Tab. 1. Coefficients γ_1 and γ_2 of the isotropic attenuation model for classes of epicentral intensity.

I_0	VI	VII	VIII	IX
γ_1	0.9872	3.0629	2.1534	1.1844
γ_2	0.2390	0.4247	0.3654	0.2501

Tab. 2. Coefficients γ_1 and γ_2 of the anisotropic attenuation model for classes of epicentral intensity.

I_0	VII	VIII	IX
γ_1	4.4144	2.1239	2.8791
γ_2	0.6606	0.3969	0.4066

4. PSHA maps with isotropic and anisotropic models

Conceptually SASHA calculates the probability distribution of the intensity expected during a defined exposure time for each locality included in the macroseismic database by reconstructing the relevant site seismic history, and assumes as value of hazard the intensity referred to a given exceedance probability. During the computation, observed data are used in a probabilistic way; for instance, uncertainty indicated in the form VIII-IX (or VII-VIII etc.), is treated by assigning 100% of probability for the lesser degree and 50% of probability for the higher degree. In this first step the hazard is therefore represented as a scattered pattern of points since the location of the inhabited centres is irregular at Etna (Fig. 2a), with the eastern flank densely urbanised, the northern and western ones hosting a few towns and the upper sector uninhabited.

In order to uniformly represent the hazard on map, SASHA can perform calculations by using a grid. In this configuration, it reconstructs the seismic history at each grid node (spacing 1 km both in longitude and latitude) by selecting, for each earthquake of the dataset, the maximum value of the intensity observed (I_{site}) inside the circle with radius of 1 km from the node centre. As explained above, if I_{site} data is missing, the "virtual" intensity (I_{calc}) is computed by the aforementioned attenuation models, and then integrated with observed data. Therefore, for each grid node, the hazard obtained by SASHA is then the highest value of intensity having an exceedance probability ≥ 10% (I_{ref}) expected in a given exposure time.

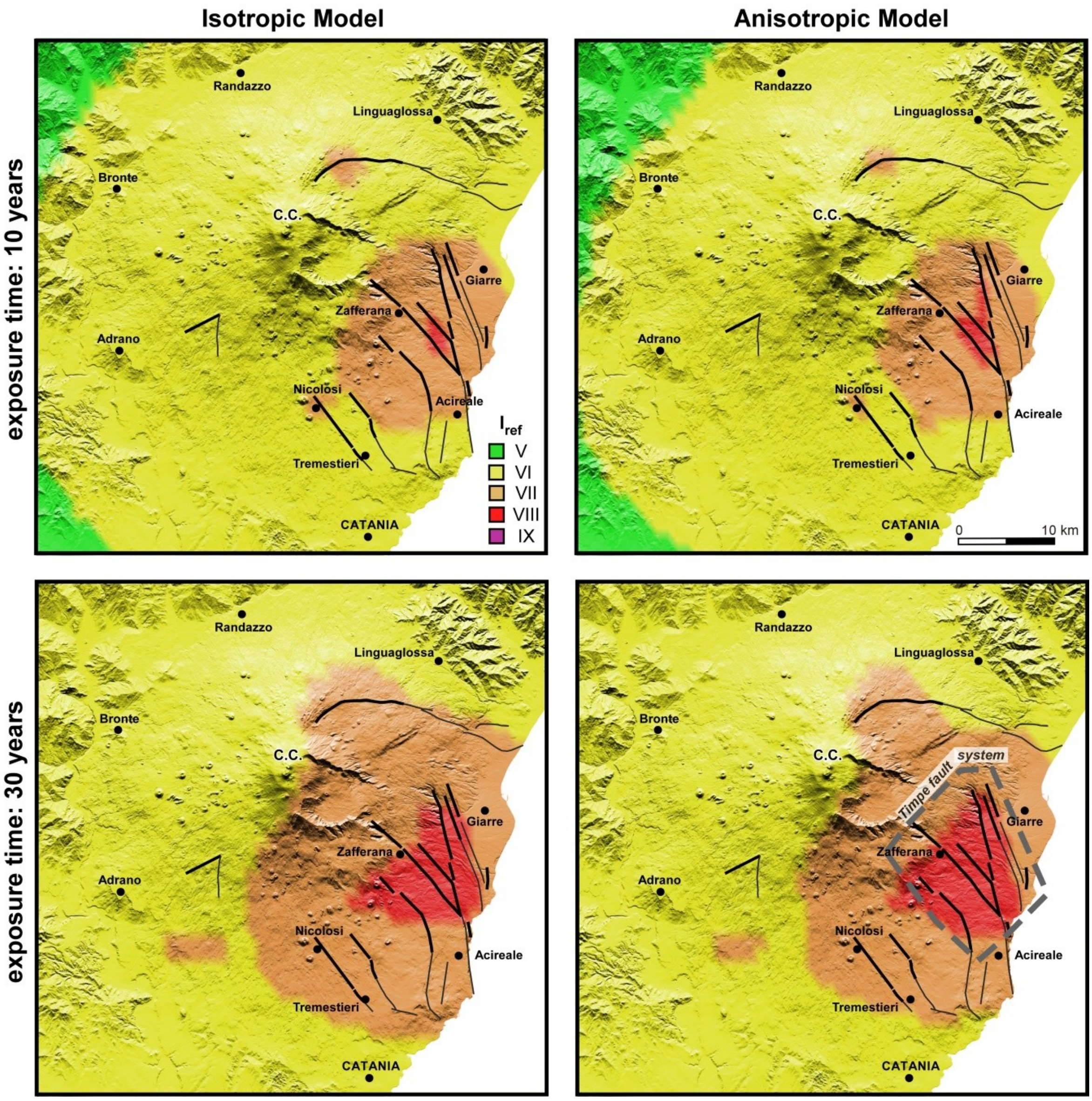

Fig. 3. Seismic hazard maps obtained using only the "virtual" intensities (I_{calc}) calculated by the specific attenuation models for Etnean volcano-tectonic seismicity. The values of expected intensity (I_{ref}) are calculated for exposure times of 10 and 30 years and refer to an exceedance probability ≥ 10%.

The probability distribution of the expected intensities at the grid nodes has been calculated for exposure times of 10 and 30 years. To evaluate the performance of both the isotropic and anisotropic attenuation models on the final maps, we first computed hazard maps using only the calculated intensities (I_{calc}), so that results are not influenced by the observed data, which in the SASHA procedure have otherwise priority. Most of the earthquakes are attenuated according to the symmetric (isotropic) spreading whereas 15 events, the strongest ones ($I_0 \geq$ VII EMS) characterized by evidence of coseismic surface faulting and associated with a causative fault (Azzaro 1999), are modelled as extended fault sources and hence processed following the anisotropic spreading (for details see Azzaro et al. 2013b). Fig. 3 shows the maps obtained according to the isotropic and anisotropic models of attenuation for the given exposure times. In general it can be observed that the zone affected by the highest hazard coincides with the area crossed by the Timpe fault system, in the eastern flank; in detail, the areas exposed to the maximum expected intensity, I_{ref} VIII EMS, result larger using the anisotropic model. This is in agreement with the elongated distribution of damage actually observed in the epicentral area, along the strike of the seismogenic structure. Conversely, the areas exposed to degree VII appear slightly broader in the isotropic model. However, the difference is trivial if the small scale of the maps is taken into account.

The final PSHA estimations are therefore computed by integrating the observed and calculated intensity data, and applying both the isotropic and anisotropic models. Fig 4 shows the expected intensities (I_{ref}) which have been obtained for some representative localities in the study area, compared with the maximum intensities that were historically observed in the same sites (I_{max}obs). In some localities (Acireale, Zafferana, Nicolosi, Linera) the same expected intensity value (I_{ref}) is obtained at 10 and 30 years of exposure time, i.e. the probability exceeds 10% quickly. Moreover in some cases Zafferana, in part also Nicolosi taking account of the uncertainty of the intensity estimation (VII-VIII) - I_{max}obs is comparable to I_{ref}, whereas in others it is the contrary (Acireale). The example of the village of Linera is anomalous, since I_{ref} does not reach I_{max}obs either for an exposure time of 30 years; this may depend on an overestimation of I_{max}obs - the degree IX-X EMS was determined by the 1914 Linera earthquake (see Langer et al. 2015) - as well as on a significantly longer recurrence time of this intensity value than the exposure time considered here. As a matter of fact, I_{ref} calculated for an exposure time of 50 years reaches degree IX EMS.

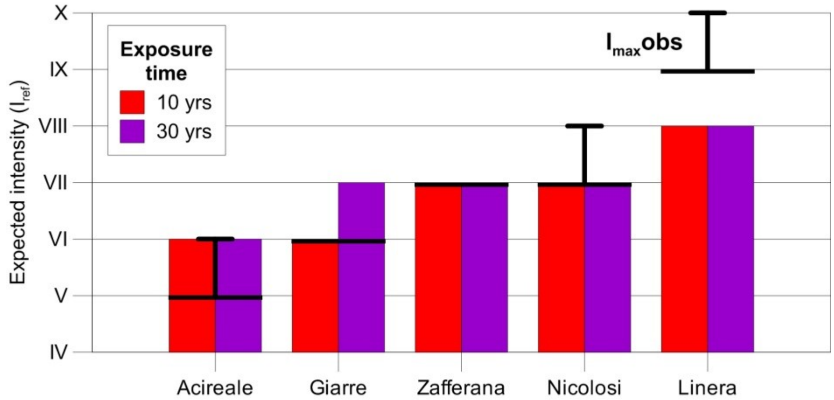

Fig. 4. Expected intensities (I_{ref}) with exceedance probability ≥10%, for some localities of the Etna region. Error bars indicate, for each site, the maximum observed intensity (I_{max}obs) with related uncertainty.

The final maps calculated for exposure times of 10 and 30 years are shown in Fig. 5. These confirm the pattern of hazard in the eastern flank presented in Fig. 3 (only "virtual" data), with the highest values of I_{ref} confined to the Timpe fault system. In particular the map calculated for 10 years of exposure time, a representative interval of the high seismic rate at Mt. Etna, shows a maximum value of I_{ref} VIII along the strike of the Timpe fault system, whereas I_{ref} VII affects a wider area as far as Zafferana and some places along the Pernicana fault and the village of Nicolosi, at the northern tip of the Tremestieri fault.

The map calculated for 30 years of exposure time shows a similar pattern, but the extension of I_{ref} VIII area now embraces the whole sector of the Timpe faults and I_{ref} VII affects a large part of the eastern flank. Moreover a spot of I_{ref} IX occurs at the northern tip the Moscarello fault, where the seismic history is characterized by two I_0 ≥ VIII-IX events occurring in 1865 and 1911 (the village of Fondo Macchia was totally destroyed and since then never reconstructed!). As for the rest of the Etna region, both maps are characterized by a background value of I_{ref} VI, with some spots of I_{ref} VII at 30 years around the seismogenic zones in the south-western sector of the volcano.

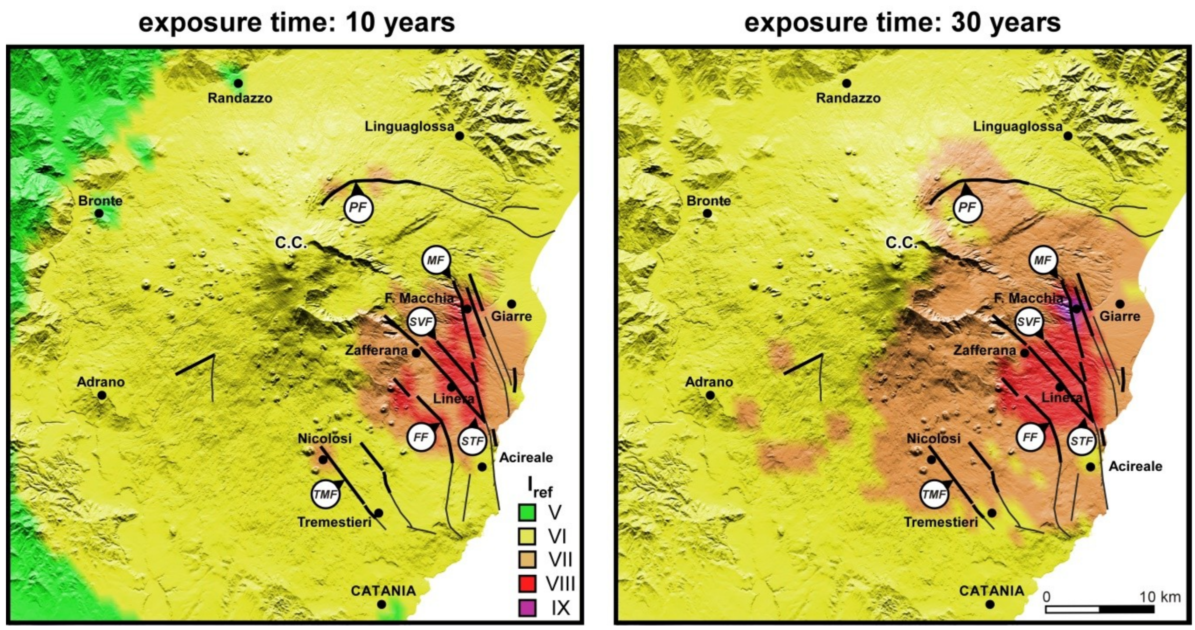

Fig. 5. Seismic hazard maps calculated for exposure times of 10 and 30 years obtained by integrating observed (I_{site}) and "virtual" (I_{calc}) intensities; the values of expected intensity (I_{ref}) refer to an exceedance probability ≥ 10%. Fault abbreviations: FF, Fiandaca fault; MF, Moscarello f.; PF, Pernicana f.; STF, S. Tecla f.; SVF, S. Venerina f.; TMF, Tremestieri f.

5. Hazard disaggregation analysis

An original procedure has recently been developed by Albarello (2012) to provide the "design earthquake" for a given locality, obtained from the probabilistic hazard discussed above. The starting point is the value of I_{ref} obtained by the statistical analysis of the seismic history. On this basis, a search of the past earthquakes that contributed most to the hazard is carried out. Since the events are characterized in terms of magnitude and epicentral location, it is possible to identify the most significant magnitude/distance bins, namely the "design earthquake". In this framework, the "design earthquake" represents a class of seismic events that actually occurred in the past and that can be identified. It is worth noting that it does not necessarily correspond to a single earthquake, since a number of events located at similar epicentral distances and with similar magnitude could contribute (Albarello 2012).

In this study, we performed the disaggregation analysis for some localities of the eastern flank of Etna, in order to determine the most representative magnitude/distance bin for the hazard at a given site. This function has been implemented in the SASHA code in the framework of the UPStrat-MAFA project (D'Amico et al. 2015a): the program gives as output the list of events contributing to the I_{ref} determination, and the probability that an earthquake has an intensity not less than I_{ref} at each site. As explained in Albarello (2012), these values can be represented in a disaggregation matrix, where for each bin of magnitude and distance, the normalized sum of the probability in the bin is reported. The earthquake corresponding to the maximum value of the paired distance/ magnitude can be assumed to be the most "representative" event in the hazard estimation.

In our analysis, the probability values of I_{ref} are binned into classes of epicentral distances (2 km) and magnitude (0.5 unit). The probability values for each earthquake are summed up in the associated distance/magnitude bins, and normalized to provide the disaggregation of data (Fig. 6a). Since most of the major earthquakes (I_0 ≥ VII EMS) considered here are associated with a fault, the disaggregation analysis can also be made by examining the seismogenic sources (Fig. 6b). The results obtained for a few representative sites of different hazard situations such as Linera, Zafferana and Acireale, are discussed in brief here; they refer to exposure times of both 10 and 30 years (for the reason why, see Fig. 4). In the case of Linera, it is evident that the contribution to the local hazard derives from earthquakes with magnitude classes ranging from 4.0 to 5.0 located very close (1 km) to this site, which are generated by the S. Tecla fault (the village centre is located astride the fault line!); also the S. Venerina fault contributes with moderate events. The hazard determined for Zafferana depends on low and high magnitude shocks ($3.5 \leq M \leq 5.0$) generally located at greater epicentral distances (4-6 km), due to the S. Tecla and Moscarello faults. Finally as regards Acireale, whose hazard is low (I_{ref} is only VI), the contribution to the hazard comes from earthquakes with moderate energy (3.5≤ M≤4.5) occurring at a certain epicentral distance (6-12 km), generated by all the structures of the Timpe system.

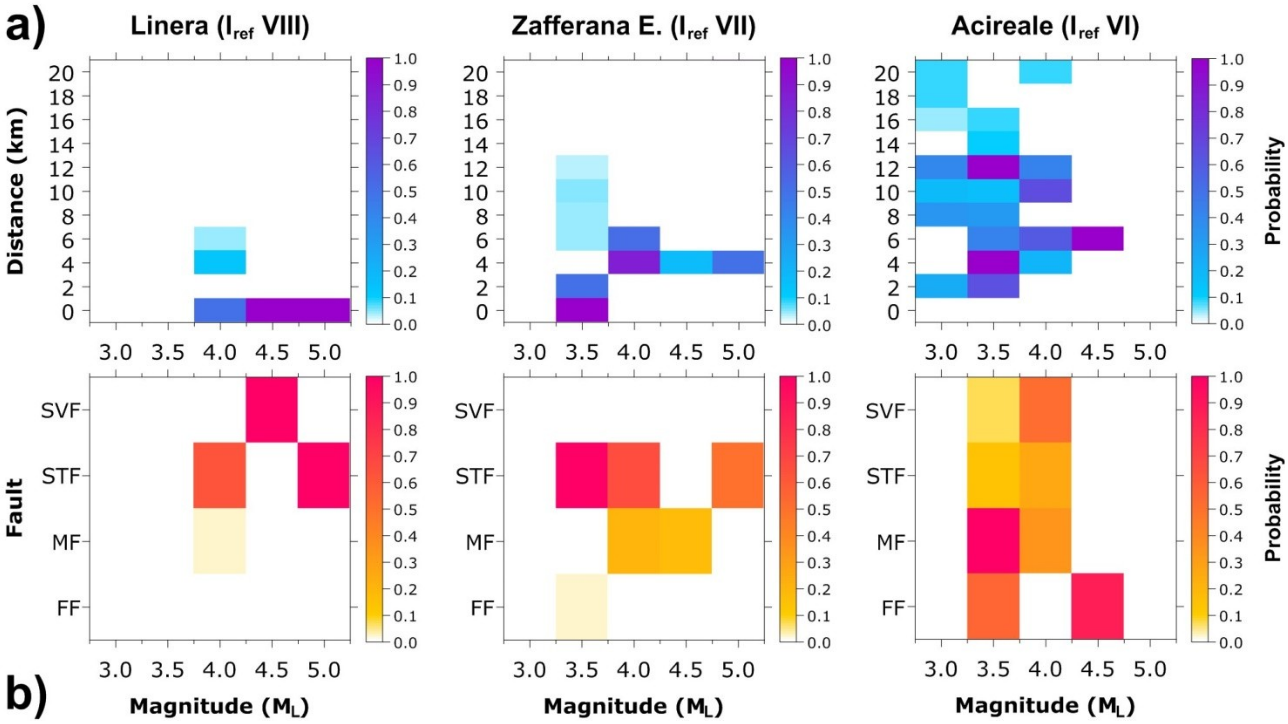

Fig. 6. Disaggregation of magnitude (bin 0.5) versus a) epicentral distance and b) seismic sources (Timpe system, fault abbreviations as in Fig. 5) for some representative localities on Etna's eastern flank.

6. Conclusive remarks

A detailed analysis of hazard is the first step in the process of seismic risk evaluation on an urban scale – the main goal of the UPStrat-MAFA project – since it provides indication for eventual interventions and possible earthquake scenarios. Continuing the approach started some years ago, based on the use of macroseismic data according to the methodology developed by Albarello and Mucciarelli (2002) and then implemented into the SASHA code by Albarello and D'Amico (2008), in this paper we present an upgrade of PSHA at Etna that exploits the results from tasks A and B of the project. Using an upgraded intensity database (1600-2013) of the Etnean earthquakes, new specific coefficients in the probabilistic attenuation models (Rotondi et al. 2015) and supplementary tools of the SASHA code (D'Amico et al. 2015a) to perform disaggregation of hazard data, we have produced seismic hazard maps calculated for exposure times of 10 and 30 years and expressed in terms of expected intensity with a probability of exceedance of 10% (I_{ref}).

The maps calculated for short exposure times and local volcano-tectonic seismic sources show the variability of hazard across the volcanic edifice with a much higher resolution than the maps at the scale normally used for the national territory (Gòmez Capera et al. 2010), with values of maximum expected intensity (I_{ref}) still being relevant in terms of risk. Indeed, the eastern flank of Etna, which is highly urbanized with more than 25 municipalities characterized by varying degrees of building vulnerability (D'Amico et al. 2015b) and a complex network of essential infrastructures and lifelines (Meroni et al. 2015), is affected by a high level of hazard with I_{ref} values up to VIII EMS even for an exposure time of 10 years (Fig. 5). The most exposed area lies in a zone in between the towns of Acireale, Giarre and Zafferana, numbering 9 municipalities in all, and crossed by the faults of the Timpe system. Here I_{ref} may increase, locally, up to degree IX EMS for an exposure time of 30 years.

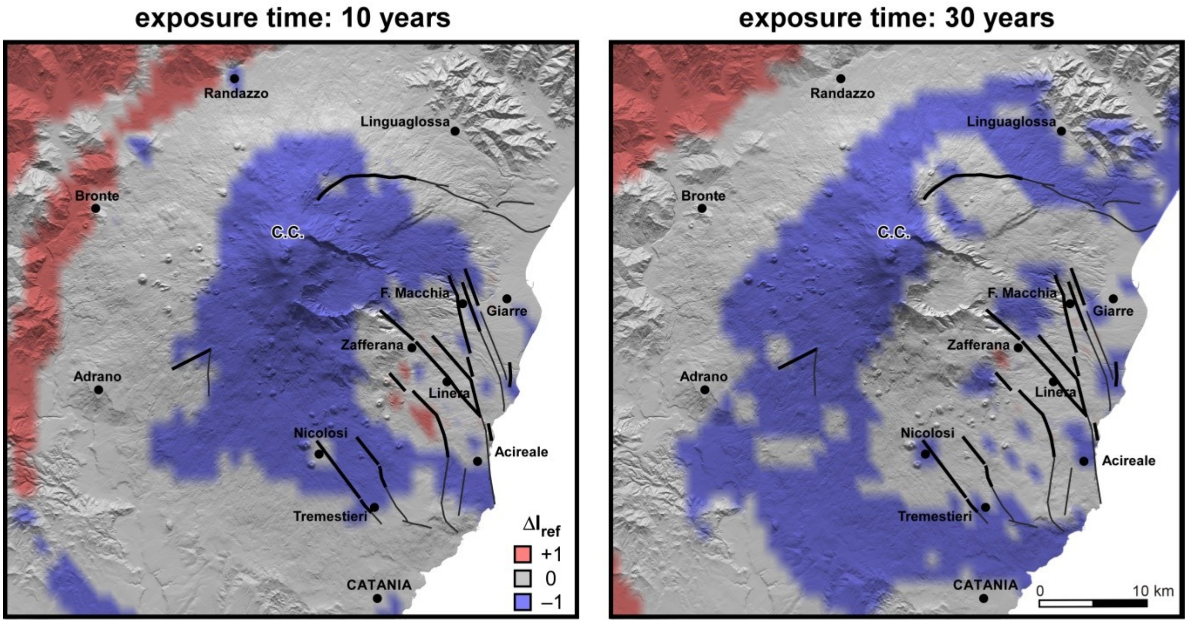

Fig. 7. Distribution of residuals for values of expected intensity I_{ref} among the hazard maps presented in this study (Fig. 5) compared with those obtained by Azzaro et al. (2013b). In blue, negative values where I_{ref} obtained in this study is lower than one degree; in red, positive values where I_{ref} now results higher than one degree; in grey, no difference.

In general this pattern is broadly consistent with the previous PSHA in the areas where the highest level of hazard is expected, i.e. the eastern flank of Etna. This comparison is presented in Fig. 7 and can be evaluated on the basis of the total residuals, calculated as the difference between the I_{ref} values represented in the maps of this study (Fig. 5) and the ones obtained by Azzaro et al. (2013a), for the same exposure times of 10 and 30 years. Negative values are represented in blue and indicate areas where the expected intensities (I_{ref}) obtained in this study are lower than one degree; on the contrary, positive values in red, mark sectors where I_{ref} is now higher than one degree; finally, the grey indicates no difference.

In practice, this means that the most hazardous area remains stable (grey in Fig. 7) in the near fields of the seismogenic zones of the eastern flank, where the contribution of observed intensity data in the most densely inhabited zone of Etna prevails. On the contrary, in the little urbanized or uninhabited central sector of the volcano the hazard essentially derives from calculated intensities obtained by the attenuation models, that in this study reproduce lower I_{ref} values (blue in Fig. 7). Lastly regarding the positive residuals (red in Fig. 7), it should be stressed that there is only a slight difference in very small areas of the eastern flank due to the use of the anisotropic model in the near field of faults – note that the same effect is also observed for negative residuals. The red ring in the western periphery of the volcano is indeed related to the higher attenuation resulting from the models used in study on the long distances.

Furthermore the disaggregated data analysis performed on some key localities of the study area, enabled defining the "design earthquake" – and hence the causative fault – which most contributes to the hazard at a site-scale. The S. Tecla fault proved to be one of the most significant structures in the Etna region.

These findings indicated the zone to be investigated in detail in the framework of tasks E and F of the UPStrat-MAFA project, aimed at evaluating the seismic risk. In conclusion, since the site of Fondo Macchia is now uninhabited - the area is used for agricultural activities – and previous time-dependent hazard analyses indicate the S. Tecla fault as the most probable structure to slip in the next 5 years (Azzaro et al. 2013a), we thus selected the maximum event historically generated by this fault, i.e. the 1914 Linera earthquake (I_0 IX-X EMS, M_L 5.2) as being worthy of attention. This was then used in the framework of task C on synthetic simulations in order to produce seismic scenarios (Langer et al. 2015), and task F on the quantitative risk evaluation and mapping by *Disruption Index* (Meroni et al. 2015).

Acknowledgments

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